UNCLASSIFIED

| AD NUMBER |
| --- |
| AD368418 |
| **CLASSIFICATION CHANGES** |
| TO: unclassified |
| FROM: confidential |
| **LIMITATION CHANGES** |
| TO: Approved for public release, distribution unlimited |
| FROM: Distribution: Controlled: all requests to Director, Naval Research Lab., Washington, D. C. |
| **AUTHORITY** |
| Aug 1972, Group-4, DoDD 5200.10; NRL ltr, 26 Feb 2001. |

THIS PAGE IS UNCLASSIFIED

Cy. 7

CONFIDENTIAL

NRL Memorandum Report 754

368418

AD No. ______

DDC FILE COPY

# SUMMARY OF NAVY STUDY PROGRAM FOR F4H-1 WEAPON SYSTEM

(Unclassified Title)

## VOLUME XIII


Equipment Research Branch
Systems Section


August 1960

~~In addition to security requirements which apply to this document and must be met, each transmittal outside the Department of Defense must have prior approval of the Director, U.S. Naval Research Laboratory, Washington, D.C. 20390.~~

DEPARTMENT OF THE NAVY · OFFICE OF NAVAL RESEARCH


U. S. NAVAL RESEARCH LABORATORY
Washington, D.C.




CONFIDENTIAL

DOWNGRADED AT 3-YEAR INTERVALS
DECLASSIFIED AFTER 12 YEARS
DOD DIR 5200.10

Further distribution of this report, or of an abstract or reproduction thereof may be made only with the approval of the Director, Naval Research Laboratory, Washington 25, D. C., or of the activity sponsoring the research reported therein, as appropriate.

SECURITY

This document contains information affecting the national defense of the United States within the meaning of the Espionage Laws, Title 18, U.S.C., Sections 793 and 794. The transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

6

SUMMARY OF NAVY STUDY PROGRAM
FOR
F4H-1 WEAPON SYSTEM. VOLUME XIII (U) 8

(Unclassified Title)

[redacted] 9 Interim rept.,

Equipment Research Branch
Systems Section

11 Aug 60,

12 17p.

14 NRL-MR-754-Vol-13

10 J. Ryon, C. Loughmiller, I. Bellavin,
[redacted] 2
R. Lister M. Schmoeller.

NAVY DEPARTMENT
NAVAL RESEARCH LABORATORY
RADAR DIVISION

TABLE OF CONTENTS

ABSTRACT
(Confidential)

The Naval Research Laboratory is serving as technical directors of the Navy's Air to Air Missile Study. The results are presented in a series of volumes under NRL Memorandum Report 754. This volume is the thirteenth in the series. The study to date has been primarily concerned with the system employing the F4H-1 aircraft, the AN/APQ-72 radar and the Sparrow III6a missile. This volume represents a continuation of the study results presented in preceding volumes.

PROBLEM STATUS

This is an interim report; work on the problem is continuing.

AUTHORIZATION

NRL Problem 53R05-04
BUWEPS No. EL-42001

# SUMMARY OF NAVY STUDY PROGRAM FOR F4H-1 WEAPON SYSTEM

## INTRODUCTION

The Bureau of Naval Weapons has contracted with the Naval Research Laboratory to conduct system studies directed toward establishing the tactical use capability of the Navy's Air to Air Missile Systems. These studies are conducted under the technical direction of the Naval Research Laboratory with all inputs derived from Navy sources. To date study effort has been primarily directed toward revealing the tactical use capability of the F4H-1 Weapon System. In support of this effort, NRL has contracted with Westinghouse Air Arm Division for analytical services. Recommendations and conclusions to be drawn from analytical results are a Navy responsibility, and in particular the responsibility of the technical directors (NRL). This report is the thirteenth in a series directed toward revealing the tactical effectiveness of the F4H-1 Weapon System.

The Navy study has been, and will continue to be, a cooperative effort. Wherever possible duplication has been avoided. Input data for the study has been obtained from the government facilities which most logically would cover the particular field. For example, radar test data was obtained from NATC, Patuxent; Sidewinder performance data has been obtained from NOTS, Inyokern; and Sparrow III seeker performance data has been obtained from NMC, Pt. Mugu. In addition, the facilities of the various activities have been, in effect, pooled so that special talents and equipments can be employed. The results of NMC, Pt. Mugu simulator studies to ascertain the allowable launch error for Sparrow III, and the effects of hydraulic oil limits have been incorporated in the overall study. In addition, NMC has conducted tests to verify the vectoring accuracies and to determine if the field degradation applied to AI radar detection range in this study is valid. It is very important that everyone concerned recognize that a study such as this must be a team effort. It is just as important to continue this team effort on future studies under the Sparrow III6b and Eagle program.

The study results, to date, have been presented in Volumes I, II, III, IV, VII, VIII, IX X, XI and XII of this series (references 1 thru 10). The study effort covered by Volumes I, II, III, IV, VII, VIII, IX and X carries the system through to Sparrow III6a missile launch.

At this point it is assumed that, if the initial aircraft heading errors can be reduced to an acceptable launch error, the missile will fly perfectly to impact with the target. The probability of arrival to missile launch results presented in these preceding volumes is based upon this assumption.

The study effort covered by this and succeeding volumes is primarily concerned with the launch and missile guidance phases of the attack. The investigation of these phases of the attack has been divided into three parts and is reported on in the same fashion. These three parts are:

(1) Investigation of the tactical effectiveness of the F4H-1 System when employing the Sparrow III6a missile as defined at the start of the Navy's study. This missile is referred to throughout the text as the unimproved Sparrow III6a.

(2) Investigation of the sensitivity of system performance to Sparrow III6a parameter variations.

(3) Investigation of the tactical effectiveness of the F4H-1 system when employing the Sparrow III6a missile as defined today. This missile will be referred to as the improved Sparrow III6a.

The results of the investigation of Part (1) are detailed in Volume XI. These results will not be repeated in this volume except where necessary for cross referencing purposes. The results of the investigation of Part (2) are detailed in this volume. A succeeding volume will detail the investigation results for Part (3).

The material contained in this memorandum is intended primarily for Bureau information. As agreed during the contract negotiation phases, except for government activities, all distribution will be handled through Bureau channels.

STUDY PROCEDURE

In preceding volumes thru Volume X, the investigation of the tactical use capability of the F4H-1 Weapon System was restricted to those phases of the attack prior to missile launch. The interceptor aircraft (including pilot, radar operator and displays) target, vectoring environment, and missile launching equations were simulated. Many possible tactical situations were examined. If the F4H-1 Weapon System arrived at a point within the allowable launch ranges and launch error, the missile was assumed to behave perfectly when launched. From the many situations examined, the probability of successful arrival to missile launch was developed for each type of attack. The study effort covered by Volumes XI and XII (references 9 and 10) extends the work described in previous volumes to include missile launching and missile guidance to impact or miss at the target for the unimproved Sparrow III6a missile. The results presented previously form the basis for the input conditions of this launch and guidance investigation. Typical attack conditions were examined. The results were then presented in terms of hit or miss at the target for each run examined.

The results of the study of the system utilizing the unimproved Sparrow III6a missile were such, particularly in differential altitude attacks, that changes in missile performance were indicated. Further, work going on at Raytheon indicated that such changes were indeed underway. It thus became important at this point in the study program to examine the effect of several missile parameter variations.

## INPUT DATA

### Sparrow III6a Missile

The missile used in this phase of the investigation is the same as that described in Volume XI (reference 9) except that the following three parameters will be varied:

(1) English bias.

(2) Variation of total impulse.

(3) Variation of missile wing unlock time.

### Radar Analyses

The AI radar performance used in this phase of the study corresponds to that predicted for the AN/APQ-72(XN-3). The 85% probability of detection range for this radar against a B-47 size target flying at M 1.6 at 50,000 ft where $V_T/V_F$=0.8 is shown by Fig. 1 of reference 9. Head-on this radar has an 85% probability of detection at approximately 19 n.mi when the expected 10 db of field degradation is used. The radar has gimbal limits of $\pm 57^\circ$ in azimuth and elevation. It is currently estimated that these gimbal limits will actually be $\pm 60^\circ$. This change has not been incorporated in the study to date. A B-47 size target is used throughout this study.

## Aircraft Analyses

The basic performance of the F4H-1 aircraft has been detailed in Volumes I thru IV of this series. Changes in this performance have occurred during the study period covered by this report. However, these changes have not resulted in significant changes in system analyses results. Details of the performance changes which have occurred and which are now being used in the simulation program are given in Volume XII of this series (reference 10).

# INVESTIGATION OF EFFECT OF MISSILE PARAMETER VARIATIONS

## English Bias Removal

The first parameter change investigated was that of "English Bias" removal. This term relates to a bias inserted into the guidance loop of the Sparrow III missile while still on the aircraft such that when launched the missile will attempt to fly to the correct course, regardless of aircraft altitude, prior to locking on the target. A complete description of this bias and the way it is mechanized is given in the section entitled "Head Slaving" in the appendix to Volume XI (reference 9). The question was asked "Does the use of English bias really improve system performance?" The following limited investigation attempts to answer this question.

Table I gives the results when the missile is launched with and without "English Bias." The results given on this table for the missile with "English Bias" are repeats of information for the miss distance evaluation of the unimproved Sparrow III6a given in Volume XI (reference 9). Column 1 of this table gives the family number used for reference purposes and corresponds to the same family number as given in reference 9. Column 2 gives the box in the probability grid from which the intercept courses were initiated. A complete description of this probability grid and the weighting factors associated with each box is given in reference 9. Column 3 gives the interceptor altitude when pull-up was initiated. The range interlock condition for missile launch is given by Column 4.

TABLE I

EFFECT OF ENGLISH BIAS REMOVAL ON
PULL-UP ATTACK RESULTS - NONMANEUVERING TARGET
$\tau_o = 0^o$ $H_T = 65{,}000$ ft $V_T = M\ 2.0$ $V_F = V_{max}$ at Pull-Up

| (1) Family Number | (2) Fighter Course | (3) Interceptor Altitude at Pull-up (ftx10$^3$) | (4) Range Interlock Condition | (5) Noise Sample | (6) English Bias Condition | (7) Overall Miss Distance $R_{MT}$ (ft) | Miss Distance at Target (8) $R_X$ (ft) | (9) $R_Y$ (ft) | (10) $R_Z$ (ft) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | D-1 | 58 | $R_{max}$ | 6 | In | 26.7 | -1.9 | 26.2 | 4.5 |
| | | | | | Out | 104.3 | -36.7 | 65.8 | -72.1 |
| | | | | 7 | In | 67.6 | -13.1 | -11.1 | -65.4 |
| | | | | | Out | 31.7 | 9.9 | -13.2 | 27.0 |
| | | | | 8 | In | 54.7 | 5.8 | -54.3 | -1.8 |
| | | | | | Out | 356.0 | -123.1 | -142.1 | -302.4 |
| | | | | 9 | In | 21.9 | -5.9 | 20.2 | -6.1 |
| | | | | | Out | 159.9 | -56.5 | 78.4 | -127.4 |
| | | | | 10 | In | 38.3 | 6.4 | 9.3 | 36.6 |
| | | | | | Out | 254.0 | -84.2 | 65.4 | -230.5 |
| | | | | No Noise | In | 11.2 | 0.4 | 1.9 | 11.1 |
| | | | | | Out | 134.4 | -47.2 | 60.2 | -110.5 |
| 2 | C-4 | 58 | $R_{max}$ | 1 | In | 69.1 | -35.8 | 59.1 | -0.1 |
| | | | | | Out | 60.2 | 26.2 | -44.2 | 31.5 |
| | | | | 2 | In | 16.3 | -0.1 | -12.5 | 10.5 |
| | | | | | Out | 44.1 | 12.8 | -12.5 | 40.3 |
| | | | | No Noise | In | 22.8 | -2.6 | 15.4 | 16.6 |
| | | | | | Out | 51.2 | 17.9 | -44.7 | -17.6 |

TABLE I (cont)

EFFECT OF ENGLISH BIAS REMOVAL ON
PULL-UP ATTACK RESULTS - NONMANEUVERING TARGET
$\tau_o = 0^o$ $H_T = 65,000$ ft $V_T = M\ 2.0$ $V_F = V_{max}$ at Pull-Up

| (1) Family Number | (2) Fighter Course | (3) Interceptor Altitude at Pull-up (ftx10³) | (4) Range Interlock Condition | (5) Noise Sample | (6) English Bias Condition | (7) Overall Miss Distance $R_{MT}$ (ft) | Miss Distance at Target (8) $R_X$ (ft) | (9) $R_Y$ (ft) | (10) $R_Z$ (ft) |
|---|---|---|---|---|---|---|---|---|---|
| 3 | D-2 | 50 | $R_{max}$ | 1 | In | 17.1 | -7.9 | 14.4 | 4.6 |
| | | | | | Out | 1865.0 | -801.5 | 559.4 | -1588.4 |
| | | | | 2 | In | 183.7 | -71.1 | -45.1 | -163.2 |
| | | | | | Out | 1902.3 | -813.4 | 513.5 | -1641.2 |
| | | | | 3 | In | 58.4 | 24.6 | -35.0 | 39.7 |
| | | | | | Out | 1859.7 | -798.6 | 541.5 | -1589.8 |
| | | | | 4 | In | 69.0 | -44.5 | 0.3 | -52.7 |
| | | | | | Out | 1876.6 | -806.9 | 565.9 | -1597.0 |
| | | | | 8 | In | 34.1 | 0.7 | -20.1 | 27.5 |
| | | | | | Out | 1875.2 | -803.9 | 618.1 | -1577.3 |
| | | | | No Noise | In | 53.7 | 25.2 | -15.8 | 44.7 |
| | | | | | Out | 1859.8 | -801.4 | 582.0 | -1574.1 |

The investigation of the effects of removing English bias was restricted to $R_{max}$ (maximum aerodynamic range) launches. Column 5 gives the noise sample employed. The number given indicates the point on the noise distribution used for starting the run. A complete description of the noise employed in the simulation is given in reference 9. Column 6 indicates whether English bias was employed (in) or not employed (out) on the missile flights. Column 7 compares the resulting miss distances. The last three columns give the geometrical components of the miss distance. Referring to Column 7 it is seen that with few exceptions the miss distance was reduced drastically when "English bias" is employed. It is obvious, even from this limited study, that "English bias" does materially improve the overall system performance.

Variation of Total Impulse

At various times during the Navy Air to Air Missile Study Program different estimates have been made for the total impulse of the Sparrow III missile. The work detailed in preceeding volumes of this report was for the most part accomplished utilizing a missile having a total impulse of 14,600 lb-sec. This corresponds to a missile whose average velocity above that of the launching aircraft velocity is $V_o = [800 \; 1+0.41(1-P/P_{SL})]$ where $V_o$ = average incremental velocity, $P$ = pressure at altitude and $P_{SL}$ = pressure at sea level. Other estimates give a total impulse of 17,000 lb-sec and 23,000 lb-sec (Sparrow III6b). These correspond to $V_o = [1100 \; 1+0.3(1-P/P_{SL})]$ and $V_o = [1300 \; 1+0.3(1-P/P_{SL})]$. Because of these different estimates it becomes of interest to determine the resulting effect on system performance.

This phase of the study varies total impulse with all other parameters, except missile weight unchanged. The missile weight was increased to include the additional propellant weight considering that specific impulse remains constant. The results obtained are given on Table II. The purpose of this investigation was to establish the effect on miss distance of varying total impulse while holding all other values constant with one exception; the steering error was allowed to vary consistent with the new $V_o$. Referring to Columns 7 and 8 of Table II it is seen that the launch range and altitude is essentially constant (within programming limits). The first five columns of this table give initial conditions and are the same as those given previously in Volume XI (reference 9) for Families 2 and 32. Two noise samples for

TABLE II

EFFECT OF CHANGE IN TOTAL IMPULSE
PULL-UP ATTACKS
$V_F = V_{F_{max}}$ at Pull-Up $V_T$ = M 2.0

| (1) Family Number | (2) Ftr Course | (3) Initial Target Aspect Angle $\tau_o$ (deg) | (4) Target Altitude (ftx10$^3$) | (5) Ftr Altitude at Pull-Up (ftx10$^3$) | (6) Noise Sample | (7) Range Inter-lock Cond | (8) Launch Altitude (ftx10$^3$) | (9) Total Impulse lb-sec | Steering Error (deg) (10) Az | (11) El | (12) Over-all Miss Dist $R_{MT}$ (ft) | Miss Distance at Target (13) $R_X$ (ft) | (14) $R_Y$ (ft) | (15) $R_Z$ (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | C-4 | 0 | 65 | 58 | 1 | $R_{max}$ | 60.1 | 14600 | 2.987 | 6.576 | 69.1 | -35.8 | -59.11 | -0.1 |
| | | | | | | | | 17000 | 2.427 | 3.879 | 57.4 | -23.4 | 49.3 | -17.8 |
| | | | | | | | | 23000 | 1.952 | 1.594 | 80.0 | -27.8 | 65.9 | -35.9 |
| | | | | | 2 | $R_{max}$ | 60.1 | 14600 | 2.987 | 1.576 | 16.3 | -0.1 | -12.5 | 10.5 |
| | | | | | | | | 17000 | 2.427 | 3.879 | 15.4 | -3.8 | 14.2 | 4.7 |
| | | | | | | | | 23000 | 1.952 | 1.594 | 69.6 | -26.3 | 55.4 | -33.0 |
| 32 | D-2 | 45 | 75 | 40 | 1 | $R_{max}$ | 54.267 | 14600 | -0.033 | 0.446 | 36.8 | -30.0 | 0.8 | -21.3 |
| | | | | | | | 53.402 | 17000 | -0.032 | -0.134 | 19.1 | -17.6 | 4.8 | -5.4 |
| | | | | | | | 53.458 | 23000 | -0.039 | -0.641 | 35.1 | -30.7 | 16.8 | 1.3 |
| | | | | | 2 | $R_{max}$ | 54.267 | 14600 | -0.033 | 0.446 | 93.3 | -84.1 | 36.3 | -18.0 |
| | | | | | | | 53.402 | 17000 | -0.032 | -0.134 | 57.4 | -52.2 | 23.1 | -6.2 |
| | | | | | | | 53.458 | 23000 | -0.039 | -0.641 | 64.0 | -52.3 | -0.2 | -37.0 |

each total impulse condition was investigated (Column 6). Column 9 gives the total impulse employed. The steering errors (azimuth and elevation) at launch are given by Columns 10 and 11. The last four columns of this table give the resulting overall and miss distance components. Referring to Column 12 it is seen that from this limited investigation there is no significant improvement obtained by increasing total impulse while holding all other conditions fixed. In addition, there is no clear trend as to the overall effect of changing total impulse. On the basis of this very limited investigation it would appear that 17,000 lb-sec total impulse is as good as any other choise for this configuration.

### Variation of Wing Unlock Time

In this phase of the study the effects of varying missile wing unlock time, while holding all other parameters constant, was investigated. In all areas of the study reported to this point the wing unlock time was held constant at 0.4 seconds from the beginning of the ejection stroke. Two other values are investigated here (0.8 and 1.1 seconds).

The results obtained are given on Table III. The purpose of the first five columns is to establish the initial conditions for this phase of the investigation. It is seen that four families (given previously in reference 9) were examined. For each of these families two noise samples were examined (Column 6). Column 7 gives the range interlock condition (all runs examined were $R_{max}$ launches). The launch altitude is given by Column 8. The variable of interest is shown on Column 9 (wing unlock time). The next two columns give the steering errors at launch. The last four columns give the resulting overall and miss distance components. Referring to these last four columns it is seen that no clear-cut trend is evident as far as wing unlock time is concerned. Increasing the wing unlock time over that employed at the time of this study (0.4 sec) does not decrease miss distance.

## REMAINING STUDY EFFORT

The details given in this report describe the second part of the concluding phase of the Navy's Air to Air Missile Study as related to the system employing the Sparrow III6a. It is anticipated that four additional reports will be issued on the results of this study. The first will give a miss distance results for the improved (current) Sparrow III6a. The second will detail the simulation techniques used in

TABLE III

EFFECT OF VARIATION OF WING UN-LOCK TIME
PULL-UP ATTACKS
$V_F = V_{F_{max}}$ at Pull-Up  $V_T$ = M 2.0

| (1) Family Number | (2) Ftr Course | (3) Initial Target Aspect Angle c (deg) | (4) Target Altitude (ftx10³) | (5) Ftr Altitude at Pull-Up (ftx10³) | (6) Noise Sample | (7) Range Inter-lock Cond | (8) Launch Altitude (ftx10³) | (9) Wing Unlock Time (sec) | Steering Error (deg) (10) Az | (11) El | (12) Over-all Miss Dist $R_{MT}$ (ft) | Miss Distance at Target (13) $R_X$ (ft) | (14) $R_Y$ (ft) | (15) $R_Z$ (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | C-4 | 0 | 65 | 58 | 1 | $R_{max}$ | 60.103 | 0.4 | 2.987 | 6.576 | 69.1 | -35.8 | 59.1 | -0.1 |
| | | | | | | | | 0.8 | | | 54.0 | 14.8 | -44.6 | -26.6 |
| | | | | | | | | 1.1 | | | 53.7 | -8.8 | -4.2 | -52.8 |
| | | | | | 2 | $R_{max}$ | 60.103 | 0.4 | 2.987 | 6.576 | 16.3 | -0.1 | -12.5 | 10.5 |
| | | | | | | | | 0.8 | | | 28.1 | 12.7 | -19.5 | 15.9 |
| | | | | | | | | 1.1 | | | 52.8 | 13.3 | -39.8 | -32.0 |
| 9 | D-1 | 45 | 65 | 58 | 1 | $R_{max}$ | 60.695 | 0.4 | -0.144 | 0.777 | 7.4 | -1.6 | 2.1 | 7.0 |
| | | | | | | | | 0.8 | | | 6.0 | -4.9 | 2.9 | -1.7 |
| | | | | | | | | 1.1 | | | 2.7 | -2.5 | 0.9 | 0.5 |
| | | | | | 2 | $R_{max}$ | 60.695 | 0.4 | -0.144 | 0.777 | 64.2 | -45.2 | 32.5 | 31.7 |
| | | | | | | | | 0.8 | | | 49.8 | -43.2 | 24.8 | -0.2 |
| | | | | | | | | 1.1 | | | 47.6 | -41.5 | 22.1 | -7.4 |
| 19 | D-1 | 45 | 65 | 40 | 1 | $R_{max}$ | 47.464 | 0.4 | -1.052 | 2.218 | 9.6 | -1.2 | -4.3 | -8.5 |
| | | | | | | | | 0.8 | | | 63.7 | -40.1 | -8.1 | -48.8 |
| | | | | | | | | 1.1 | | | 71.3 | -54.6 | -3.4 | -45.8 |

TABLE III(cont)

EFFECT OF VARIATION OF WING UN-LOCK TIME
PULL-UP ATTACKS
$V_F = V_{F_{max}}$ at Pull-Up $V_T$ = M 2.0

| (1) Family Number | (2) Ftr Course | (3) Initial Target Aspect Angle $\tau_o$ (deg) | (4) Target Altitude (ftx10³) | (5) Ftr Altitude at Pull-Up (ftx10³) | (6) Noise Sample | (7) Range Inter-lock Cond | (8) Launch Altitude (ftx10³) | (9) Wing Unlock Time (sec) | Steering Error (deg) (10) Az | (11) El | (12) Over-all Miss Dist $R_{MT}$ (ft) | Miss Distance at Target (13) $R_X$ (ft) | (14) $R_Y$ (ft) | (15) $R_Z$ (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32 | D-2 | 45 | 75 | 40 | 2 | $R_{max}$ | 47.464 | 0.4 | -1.052 | 2.218 | 50.4 | -43.9 | 24.5 | -3.4 |
| | | | | | | | | 0.8 | | | 74.4 | -66.1 | 16.0 | -30.3 |
| | | | | | | | | 1.1 | | | 81.7 | -73.0 | 17.0 | -32.4 |
| | | | | | 1 | $R_{max}$ | 54.267 | 0.4 | -0.033 | 0.446 | 36.8 | -30.0 | 0.8 | -21.3 |
| | | | | | | | | 0.8 | | | 218.8 | -192.7 | 89.2 | -28.5 |
| | | | | | | | | 1.1 | | | 332.1 | -301.0 | 76.0 | -117.9 |
| | | | | | 2 | $R_{max}$ | 54.267 | 0.4 | -0.033 | 0.446 | 93.3 | -84.1 | 36.3 | -18.0 |
| | | | | | | | | 0.8 | | | 316.2 | -285.6 | 128.0 | -45.0 |
| | | | | | | | | 1.1 | | | 442.9 | -402.5 | 107.5 | -150.3 |

the pull-up attack investigation. The third will detail parameter variations encountered in the missile simulation and the fourth will be a formal report summarizing the results obtained in the entire study of the system employing the Sparrow III6a. There will be a continuing effort directed toward employing the results in the developing and testing of the system. When applicable, memorandum reports will be issued detailing this effort.

CONCLUSIONS AND RECOMMENDATIONS

1. A limited investigation of the effect of "English Bias" removal on pull-up attack results indicates the necessity for some form of pre-lock guidance.

2. A limited investigation (2 runs for each of two conditions, see Table II) of the effect on increasing total impulse indicated no significant improvement in miss distance in pull-up attack results against high speed, high altitude targets. It appears that 17,000 lb/sec total impulse is as good as any other choice for this configuration.

3. A limited investigation of the effect on pull-up attack results of varying missile wing unlock time reveals no reduction in miss distance with increase in the unlock time over that currently employed (0.4 sec).

ACKNOWLEDGEMENTS

The data presented in this report represents the results, to date, of the Navy's Air to Air Missile Study Program. The analytical results including those from which the figures were derived are the results of the computational work underway at Westinghouse Air Arm Division. A large portion of the data reduction required for material presented in this volume was actually accomplished at Westinghouse and reviewed for accuracy by the Technical Directors. In addition, results of analysis underway at NMC, Pt. Mugu are included. The data from which the definition of the Sparrow III missile and the AN/APA-128 computer resulted were obtained from the Raytheon Mfg. Co. Definition of the aircraft performance resulted from the cooperative effort of the McDonnell Aircraft Co. Test data on AI radar performance was obtained from NATC, Patuxent. The authors would like to thank members of these activities for their cooperation.

This report was prepared by the following members of the Systems Section, Equipment Research Branch:

J. Ryon
C. Loughmiller
I. Bellavin
R. Lister
M. Schmookler

## REFERENCES


1. "Summary of Navy Study Program for F4H-1 and F8U-3 Weapons Systems, Volume I," NRL Memorandum Report 754, November 1957 Confidential

2. "Summary of Navy Study Program for F4H-1 and F8U-3 Weapons Systems, Volume II, Appendices to NRL Memorandum Report 754," Confidential

3. "Summary of Navy Study Program for F4H-1 and F8U-3 Weapons Systems, Volume III," NRL Memorandum Report 754, May 1958, Confidential

4. "Summary of Navy Study Program for F4H-1 and F8U-3 Weapons Systems, Volume IV, Appendices to NRL Memorandum Report 754," Confidential

5. "Summary of Navy Study Program for F4H-1 and F8U-3 Weapons Systems, Parameters Plots for Co-Altitude Attacks, Volume VII," NRL Memorandum Report 754, Confidential

6. "Summary of Navy Study Program for F4H-1 and F8U-3 Weapons Systems, Parameter Plots for Pull-Up Attacks, Volume VIII," NRL Memorandum Report 754, December 1958, Confidential

7. "Summary of Navy Study Program for F4H-1 Weapon System, Volume IX," NRL Memorandum Report 754, November 1959, Confidential

8. "Summary of Navy Study Program for F4H-1 Weapon System Parameter Plots for Pull-Up Attacks, Volume X," NRL Memorandum Report 754 (in preparation) Confidential

9. "Summary of Navy Study Program for F4H-1 Weapon System, Volume XI," NRL Memorandum Report 754 (in preparation) Confidential

10. "Summary of Navy Study Program for F4H-1 Weapon System, Volume XII, Appendices to NRL Memorandum Report 754," Confidential

# Naval Research Laboratory
# Technical Library
# Research Reports Section

**DATE:** February 26, 2001

**FROM:** Mary Templeman, Code 5227

**TO:** **Code 5300 Paul Hughes**

**CC:** Tina Smallwood, Code 1221.1 ts 3/8/01

**SUBJ:** Review of NRL Reports

Dear Sir/Madam:

1. Please review NRL Report MR-754 Volumes I, II, III, IV, VII, VIII, IX, X, XI, XII, XIII, XIV, XV, MR-1372 and MR-1289 for:

- [x] Possible Distribution Statement
- [ ] Possible Change in Classification

Thank you,

Mary Templeman

Mary Templeman
(202)767-3425
maryt@library.nrl.navy.mil

---

The subject report can be:

- [x] Changed to Distribution A (Unlimited)
- [ ] Changed to Classification __________
- [ ] Other:

Ben H Cantrell 3-8-01

Signature Date

** MAY CONTAIN EXPORT CONTROL DATA **



AN (1) AD- 368 418/XAG
FG (2) 160400
160401
CI (3) (U)
CA (5) NAVAL RESEARCH LAB WASHINGTON D C
TI (6) SUMMARY OF NAVY STUDY PROGRAM FOR F4H-1 WEAPON SYSTEM. VOLUME XIII.
DN (9) Interim rept.
AU (10) Ryon ,J.
Loughmiller ,C.
Bellavin ,I.
Lister ,R.
Schmookler,M.
RD (11) Aug 1960
PG (12) 17 Pages
RS (14) NRL-MR-754-Vol-13
RC (20) Unclassified report
NO (21) See also Rept. no. NRL-MR-754-Vol-14, AD-368 419L.
AL (22) Distribution: Controlled: all requests to Director, Naval Research Lab., Washington, D. C.
DE (23) (*WEAPON SYSTEMS, NAVY) (U) AIR TO AIR MISSILES
RADAR TRACKING, SEARCH RADAR, AIRCRAFT FIRE CONTROL SYSTEMS, JET FIGHTERS
DC (24) (U)
ID (25) AN/APQ-72, F-4 AIRCRAFT, SPARROW
IC (25) (U)
DL (33) 05
CC (35) 251950